Lat 39.55883 and Lon -120.49173

Forest Health Protection
Pacific Southwest Region

Date: August 19, 2013

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To: District Ranger, Sierraville Ranger District, Tahoe National Forest

Subject: Forest Health Protection input to the Ox Project (FHP Report NE13-05)

On June 10, with Teri Banka (District Silviculturist), Bill Woodruff (FHP Plant Pathologist) and Danny Cluck (FHP Entomologist) evaluated portions of the Ox Project for forest insect and disease considerations. On July 23, Woodruff and Banka revisited the Ox Project with white pine blister rust (WPBR) specialists Detlev Vogler (PSW Research Geneticist), Tom Blush (R5 Geneticist) and Joan Dunlap (Forester, R5 WPBR Resistance Program).

The Ox Project proposes to manage western white pine (WWP), red fir (RF), white fir (WF), lodgepole pine (LPP) and Jeffrey pine (JP) above 7,000 feet elevation near the Sierra Nevada crest south of Yuba Pass on CA Hwy 49 in Sections 11, 14 & 34, T20N, R13E, Mt. Diablo Meridian. In the late1950s and early 1960s the proposed Ox Project units were treated with sanitation-salvage treatments; and in the 1980s some of the units were regenerated using shelterwood prescriptions. Management direction allows removal of trees less than 30" DBH while maintaining minimum crown closure in certain areas. The objectives of the Ox Project are to hasten the development of large-size trees and to release from competition WWP seedlings and saplings; with emphasis on preserving white pine blister rust resistance in the WWP while minimizing insect and disease impacts on all tree species.

Figure1. WWP sapling with a WPBR canker growing into the bole from an infected branch. Orange blisters contain aeciospores of the rust fungus *Cronartium ribicola.*

Insect and Diseases in the Ox Project:

White pine blister rust (WPBR) caused by *Cronartium ribicola*: WPBR signs or symptoms (Figure 1) were found in all Ox Project units. Seedlings, saplings and mature WWP with dead or dying tops (Figure 2), branches and/or WPBR cankers were readily found, indicating that the area is at risk for future WPBR infections. A large number of mature WWP have older-dead or flagging branches, probably killed by WPBR. However, a large number of WWP appeared to be free of WPBR. Signs on numerous WWP trees of all sizes appeared to be the result of 'slow rust' WPBR resistance. The possible WPBR slow rust resistance in WWP in the Ox Project is of interest to the WPBR specialists. A small number of ripe cones from a small number of superior trees can be sent to the R5 WPBR Resistance Program for evaluation, if desired.

Three *Ribes* species were found in the Ox units; all had WPBR uredial spores on July 23rd. An attempt was made to age a few WPBR cankers by counting the branch whorls that grew distal to the cankers. Estimated ages varied widely. It appears that WPBR wave years (years of widespread heavy WPBR infection) occur infrequently. In between wave years, WPBR infections on WWP probably occur randomly in the Ox Project during favorable microclimate conditions. Overall, the WPBR in the Ox Project area appears not to be devastating to the WWP. Therefore, managing for current and future mature WWP with the existing level WPBR appears to be a low risk option; especially if WWP without signs of WPBR are favored.

If the climate warms in the future, some experts believe that WPBR will be less impacting on white pines in the Sierra Nevada range because *Cronartium ribicola* is considered a cool weather disease. To the contrary, these experts also say that WPBR could become more impacting in the event more precipitation occurs when rust spores are present and susceptible host needles are available. Thus, there is no way of knowing for sure whether climate change will increase or decrease WPBR on WWP in the Ox Project.

Figure 2. WWP sapling with dead top resulting after bole was girdled by a WPBR canker.

Dwarf mistletoe of white and red fir (*Arceuthobium* spp.)

True fir dwarf mistletoe (Figure 3) is growing in many fir trees of all sizes in the units. True fir dwarf mistletoe, *Arceuthobium abietinum* f. sp. *magnificae* and *A. abietinum* f. sp. *concolor,* are host-specific seed-bearing plants that parasitize red and white fir, respectively. This parasite weakens host trees by stealing water and nutrients needed by the host. True fir dwarf mistletoe does not spread rapidly. Vertical spread in a tree averages less than 3 inches per year. Horizontal spread in a stand without overstory infection is also quite limited. The dense foliage of true firs limits spread because of the high probability of interception of the seed. Spread of dwarf mistletoe seeds from infected overstory to understory trees is limited to the distance the seeds travel after being forcibly discharged. From overstory to understory, the distance is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. Trees less

Figure 3. Dwarf mistletoe plant infecting a swollen white fir branch.

than 3 feet tall have a limited chance of becoming infected because their small size presents a small target with a low probability of being hit by a randomly discharged seed.

Spread of dwarf mistletoe from overstory trees to understory host trees is considered to be the most damaging way this parasite proliferates. Past shelterwood treatments in the Ox Project area successfully regenerated true fir and WWP most effectively. Not removing the infected overstory fir trees in a timely manner following the regeneration allowed the dwarf mistletoe to infect many of the understory fir. The best treatments for limiting future spread and intensification of the dwarf mistletoe are: 1) remove or girdle all infected overstory true fir trees which have desireable understory fir crop trees; 2) remove all dwarf mistletoe-infected understory fir trees (while releasing rust free WWP in the process); and 3) return in five year to remove fir with dwarf mistletoe that developed from latent infections or prune all dwarf mistletoe-infected branches from the remaining fir regeneration. Alternatively, where dwarf mistletoe infected overstory fir trees will remain at the completion of the Ox Project, all understory fir regeneration could be removed from within 60 feet of the infected overstory fir trees and rust resistant WWP could be planted in their place. Note: Managers might consider the remote possibility that dwarf mistletoe free fir seedlings and saplings growing under heavily dwarf mistletoe infected overstory fir trees are resistant to the parasite; and retain those trees to monitor for resistance. Openings created in the Ox Project should be planted with rust resistant WWP seedlings to reduce the future impact of rust on WWP.

Heterobasidion root disease caused by *Heterobasidion occidentale*

Fruiting bodies (conks) of *Heterobasidion occidentale* (Figure 4) and delaminated wood were readily found in fir stumps or wood of upturned roots in the Ox Project; thus confirming that *Heterobasidion* root disease is present. Other symptoms of root disease found in the true fir in the project are declining crowns (dead branches and sparse foliage), stunted tree growth (e.g. short leader growth and rounded tops), and windthrow. Even though symptoms were readily found, the crowns of the fir in the areas visited appeared relatively healthy. Only a few small areas in the project exhibited symptoms of advanced root disease (i.e. fir snags, blown-down fir trees, decayed root and stump wood, short leader growth on understory fir trees, or seriously declining old-growth crowns). The areas with the worst root disease symptoms in the Ox Project would be the best places to clear and plant with rust resistant WWP. The restriction from harvesting any tree larger than 30" DBH limits the control options for both the *Heterobasidion* root disease and the true fir dwarf mistletoe infestation. Root disease can be partially treated by removing all fir less than 30" DBH which have poor crowns (short leader growth, heavy dwarf mistletoe or decline); thereby using individual tree selection to remove diseased trees and reduce tree densities which can improve growth and vigor in leave trees following treatment. Even though many of the roots of the leave fir trees will remain infected with *H.occidentale*, the impact of this disease should be reduced because trees with increased vigor can grow wood faster at the exterior of their roots' cross section than the *Heterobasidion* fungus decays in the interior of the roots.

Figure 4. *Heterobasidion occidentale* fruiting body from a decaying fir stump in the Ox Project.

Mountain pine beetle (*Dendroctonus ponderosae*) in western white and lodgepole pine

Mountain pine beetle was observed infesting WWP and LPP in one small area (Figure 5). Although most of the project area has not experienced mountain pine beetle activity, higher stand density in areas with a high percentage of WWP and LPP have the potential for elevated tree mortality. The risk of beetle feeding is increased during periods of drought. Thinning stands to lower stocking levels is highly recommended. Thinning provides more site resources for growing healthy trees and provides more opportunities for natural WWP regeneration.

Figure 5. Woodpecker feeding on WWP bole infested with mountain pine beetles and larvae.

Improving the health and vigor of old growth trees in the Ox Project

Radial thinning could be implemented in the Ox Project to improve the health of selected old growth WWP where canopy restrictions allow. Radial thinning consists of removing understory trees from around residual old growth trees. FHP monitoring has shown that old growth ponderosa, Jeffrey and sugar pine respond with an increase in growth when trees were cleared out to at least 30' from the bole. No information exists regarding radial thinning treatments around WWP; so, if implemented, the effects of radial thinning around old growth WWP should be monitored and documented.

The health of declining old growth trees (i.e. heavily impacted by root disease or dwarf mistletoe; or with otherwise damaged, deformed or dying crowns) will probably not be improved. Trees and regeneration with poor crowns and sparse foliage should be removed or killed to improve the health and vigor of the leave trees so they can better tolerate the impacts of insects, disease and drought. Most overstory old growth trees with seriously declining crowns remaining in the Ox Project following treatment will soon die. Retaining high risk trees in the Ox Project will reduce the timber yield, but ultimately these trees can improve the ecosystem because, after they die, the snags will decay and collapse over time and contribute to soil structure and fertility. In the process, the standing large snags should benefit numerous and varied wildlife species as they slowly deteriorate.

Please see attached for more information on *Heterobasidion* root disease, white pine blister rust, dwarf mistletoe and mountain pine beetle. If you have any questions regarding this report and/or need additional information please contact Bill Woodruff at 530-252-6680.

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DISEASE AND INSECT BIOLOGIES:

White pine blister rust

White pine blister rust is caused by Cronartium ribicola an obligate parasite that attacks 5-needled pines and several species of Ribes spp. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes spp. The disease occurs throughout the range of sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on pine bole or branch cankers are wind-disseminated to Ribes spp. where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves reinfect other Ribes spp. throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on Ribes spp. leaves in the fall. Teliospores germinate in place to produce spores (sporidia) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes spp. to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes spp., its spread from Ribes spp. back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers that have margins more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result.

True Fir Dwarf Mistletoe

True fir dwarf mistletoe, *Arceuthobium abietinum* f. sp. *magnificae* and *A. abietinum* f. sp. *concolor* are seed-bearing plants that parasitizes red and white fir, respectively. They are parasites that cannot survive without living host tissue, which they depend on for support, food, nutrients and water.

Dwarf mistletoes initiate their life cycle when a seed lands on a needle or small twig of a host. The seed is coated with viscin, a sticky substance that allows it to adhere to the host tissue. During rains, the viscin becomes mucilaginous, allowing the seed to slide down to the needle base where it may lodge. The seed germinates in the winter or spring and the radicle grows along the twig until it reaches a needle base or bark irregularity. The radicle forms a holdfast and penetrates the twig into the xylem. A type of root system then develops in the twig. In 3 to 5 years from seed deposition, most successful infections will appear as branch swellings and will bear mistletoe shoots. These shoots generally produce fruit 1 to 2 years later. Fruit mature in the fall and disseminate seed in September and October. The seeds are explosively discharged from the fruit through the buildup of turgor pressure. Seeds normally have an upward trajectory.

True fir dwarf mistletoe does not spread rapidly following establishment. Vertical spread in a tree averages less than 3 inches per year. Horizontal spread in a stand without overstory infection is also quite limited. The dense foliage of true firs limits spread because of the high probability of interception of the seed. Spread of dwarf mistletoe seeds from infected overstory to understory trees is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals. Trees less than 3 feet tall have a very limited chance of infection because of their small target size.

Often the canker-causing fungus *Cytospora abietis* infects true firs at dwarf mistletoe infections. *Cytospora* sometimes attacks as many as a quarter of the mistletoe-bearing branches, eventually killing infected branches. The bright red/dead branches on most dwarf mistletoe-infected red firs (and sometimes white firs) are the result of lethal Cytospora infections. C. abietis occasionally reaches especially damaging proportions in certain years.

Heterobasidion Root Disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants worldwide. All western conifer species are hosts. Madrone (*Arbutus menziesii*) and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Most hardwoods are apparently not infected. *Heterobasidion* root disease has been reported in all National Forests in California with incidence particularly high in true fir in northern California, in the eastside pine and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other impacts of the disease include: loss of tree vigor, increased susceptibility to attack by bark beetles, tree death, loss of site productivity, depletion of vegetative cover and increased probability of tree failure and hazard.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees or occasionally under the duff at the base of infected trees. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. In true fir spores also infect naturally-occurring and mechanical wounds. From infected stump surfaces the fungus grows into and through the roots, via root-to-root contact, to adjacent live host trees; resulting in the formation of expanding disease centers. A disease center can continue growing, host tree to host tree, until it reaches a barrier; such as an opening in the stand or non-host vegetation.

In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills small trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots; sometimes infecting the heartwood of the lower trunk. In all conifers, the fungus causes chronic decay and growth loss which predisposes infected trees to beetle attack and subsequent mortality.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentale* (also called the 'S' type) and *H. irregulare* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregulare* ('Pine' type) is pathogenic on most pine species (but primarily on ponderosa and Jeffrey, sugar, lodgepole, pinyon and Coulter pines), incense cedar, western juniper, madrone and a few species of brush. *H. occidentale* ('Spruce' type) is pathogenic on true fir, Douglas fir, hemlock fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentale* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for more than a quarter century. Young conifers established near infected stumps often die shortly after their roots grow in contact with infected roots.

The best control for *Heterobasidion* root disease is prevention; i.e. treating freshly cut conifer stumps with a borate fungicide. The two fungicides registered for this purpose are SPORAX® (granular) and CelluTreat® (liquid). Note: treatment of freshly-cut stumps will only protect healthy stumps and roots. In California, most true fir stands are already infected, to some degree, with *H. occidentale.* Borate stump treatment will not kill *Heterobasidion* already growing in the roots.

Once in the roots, *Heterobasidion sp.* can persist more than 25 years or until the roots decompose. As long as sound and wet wood, free of other microbes, is available, *Heterobasidion sp.* can survive. Therefore, the two primary controls for infected root systems are: 1) removing all host plants from the disease center for a quarter century, or until almost 100% of the roots have decomposed; or 2) removing all of the infected stumps and roots. The former may result in loss of site productivity and/or require managing only non-host trees on the site. The latter is usually cost-prohibitive, except in nurseries, seed orchards, administrative sites, recreation areas or high-value sites.

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae*, attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 8 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

Evidence of Attack

The first sign of beetle-caused mortality is generally discolored foliage. The mountain pine beetle begins attacking most pine species on the lower 15 feet of the bole. Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes on successfully infested trees are pink to dark red masses of resin mixed with boring dust. Creamy, white pitch tubes indicate that the tree was able to "pitch out" the beetle and the attack was not successful. In addition to pitch tubes, successfully infested trees will have dry boring dust in the bark crevices and around the base of the tree. Attacking beetles carry the spores of blue-staining fungi which develop and spread throughout the sapwood interrupting the flow of water to the crown. The fungi also reduces the flow of pitch in the tree, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the needles to discolor and the tree to die.

Life Stages and Development

The beetle develops through four stages: egg, larva, pupa and adult. The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Females making their first attacks release aggregating pheromones. These pheromones attract males and other females until a mass attack overcomes the tree. The adults bore long, vertical, egg galleries and lay eggs in niches along the sides of the gallery. The larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

Conditions Affecting Outbreaks

The food supply regulates populations of the beetle. In lodgepole pine, it appears that the beetles select larger trees with thick phloem, however the relationship between beetle populations and phloem thickness in other hosts has not been established. A copious pitch flow from the pines can prevent successful attack. The number of beetles, the characteristics of the tree, and the weather affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include nematodes, woodpeckers, and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and pine mortality increases.